Douglas fir duff moisture when correlated with the average relative humidity for 60-minute periods ending one hour before the moisture measurements also gave a positive correlation of 0.97. (The sine curve analysis showed duff to have a lag of about one and one-half hours.) Correlation of the moisture in decayed wood with humidity data likewise yielded a positive correlation of 0.97. Of the 21 fuels studied, western white pine duff gave the best correlation, 0.98, and lowland white fir duff gave the poorest, 0.89.

As indicative of the sufficiency of the data for correlation purposes, the standard deviations of the correlation coefficients were found to be of the order of ± 0.01.

Estimates of current fuel moisture conditions based on atmospheric relative humidity show standard errors of estimate ranging from ± 2.3 per cent moisture for pearly everlasting down to but ± 0.3 per cent moisture for Douglas fir twigs. For example the standard error of the estimates of braken fern moisture was calculated to be ± 1.6 per cent moisture. Attaching the usual significance to the standard error of estimate it is assumed that, with a normal distribution, about two-thirds of the errors resulting from the use of the estimating equation will not exceed ± 1.6 per cent. The greatest errors were found to occur when the estimates were based on high humidity values such as often occur at night.

No attempt has been made here to evaluate the seasonal trend of fuel moisture nor the eccentric fluctuations due to precipitation, for that requires a somewhat different treatment. Nevertheless, the study does furnish a method of approximating fuel moisture during the mid-season dry weather.

It is hoped that the results of the study may be of assistance to the fire fighter in estimating the length of the fire day, its severity, and the hours of fire danger on areas where the types of fuel are known.

On going fires it should aid in anticipating the degree of inflammability of the various fuels and also aid in the proper disposition of the fire suppression forces.

Also a knowledge of the degree and rapidity with which the various kinds of forest fuels respond to relative humidity is essential to good slash burning technique. Estimates of fuel moisture should help the slash burner to calculate the proper time at which to fire his slash in order to get the best burn with a minimum danger of the fire spreading beyond the slash area.

NOTES, ABSTRACTS, AND REVIEWS

The Quarterly Journal of the Royal Meteorological Society.—Though a good many copies of the excellent Quarterly Journal of the Royal Meteorological Society are received by meteorologists in the United States, there are interested readers who may not have seen this Journal recently. A brief review of the contributions in the January, 1930, issue shows the importance of this outstanding meteorological quarterly.

M. G. Bennett discusses "The physical conditions controlling visibility through the atmosphere." First, he worked up the theory with the aid of laboratory experiments, and then tested his conclusions in the field. The relative effects of screening, diffusion, and glare upon visibility are expressed in an empirical formula. Mr. Bennett notes the difference between even change in visibility when the effect is simply one of glare, as in the case of smoke, and the sudden change from moderate visibility to no visibility in case of fog, which diffuses light.

Dr. Lewis F. Richardson presented results on "The Reflectivity of woodland, fields and suburbs, between London and St. Albans," obtained from airplanes. The reflectivity for red light ranged from slightly under 4 per cent for woodland and the reservoir to 6 per cent for brown standing wheat. For green light, the reflectivity ranged from 3½ per cent for tall woodland to 8½ per cent for bare land. The reflectivity of blue light was still less, ranging from about 2 per cent for wood land and green fields to 4 per cent in villas and gardens. The reflectivity of sand, cement slabs, or earth when dry is roughly double what it is when they are wet. The reflectivity of water, so conspicuous at nearly grazing incidence, falls off to nearly 2 per cent incidence according to Fresnel's formulæ; so that of the light reflected from the reservoir about one-half comes from below the air-water interface.

Thora C. Marwick presented observations on "The electric charge on rain," made in New Zealand. Of all the rain measured, 76.5 per cent was positively charged; of thunderstorm rain 94.6 per cent was positively charged; of ordinary rain 79.5 per cent; and of a little drizzling rain, 100 per cent. Sleety rain accompanied by hail had a considerable negative charge.

J. E. Clark, and I. D. Margary presented a general article on Floral isophenes and isakairs, for England. Phenological dates for flowering plants in England when averaged over a 35-year period are practically the same as for a 30-year period. The 35-year normals have been used as a basis for determining departures in individual years. Departures were read by comparisons between the average map and the maps for each year for each intersection of half degrees of longitude and latitude. The earliness and lateness of the season is not always related in an obvious manner to the temperature or sunshine of the preceding few months. Conditions in the previous fall may have something to do with the dates.

E. W. Bliss in "A study of rainfall in the West Indies," showed that the March to May pressures in central Siberia and Charleston, S. C., and temperatures for St. Vincent indicate the West Indies rainfall for June to December following, with the correlation coefficient of 0.69. High rainfall follows a weak Azores high. The delay is thought to depend upon the westward movement of ocean waters in the north Atlantic.

Sir Gilbert T. Walker in a note "On the mechanism of tornadoes" suggested that tornadoes are whirls essentially on a horizontal axis the equatorward end of which dips to the earth. This idea was not generally acceptable to those who discussed the paper.

Among the notes, is a discussion of "Winter thunderstorms in the British Isles," in the period from October to March, inclusive. During the past three winters the number of days on which thunderstorms occurred anywhere in the British Isles are 96, 92, 69. The stormiest regions are the west and north of Ireland, the northwest of Scotland and the English lake district.

Reviews of the book by August Schmauss, and Albert Wigand, "Die Atmosphäre als Kolloid," and of W. P. von Poletika's "Klima and Landwirtschaft Russlands," are included in this issue.—*C. F. B.*

Climatology of the Virginias [1] (*by E. Ray Casto, Emory and Henry College*) [*author's abstract*].—The Virginias lie in one of the favored climatic regions of the world. Each of the climatic factors is markedly influenced by the widely diversified topography of the region. And the divergent winds tend to equalize other climatic elements and to give less variable climate.

[1] Submitted as a thesis as part requirements of the degree of Ph. D. at Clark University Worcester, Mass., in 1926.

The average sunshine for the Virginias as a whole is above 52 per cent of the possible amount—for Virginia 56 per cent and for West Virginia 46 per cent. There is a decrease in sunshine with increase in latitude or proximity to the principal storm tracks farther north. Sunshine and cloudiness are nearly complementary. Cloudiness increases and sunshine decreases here with altitude, latitude, exposure, and relative humidity. Elkins on the windward side of the mountains has the greatest number of cloudy days, 156, and Lynchburg on the leeward side of the mountains has the least, or 93 cloudy days.

The effect of latitude on temperature is best seen in the Coastal Plain. The dominance of latitude is shown in the east-west trend of the isotherms, the temperature gradient being about 2.5° F. per latitude degree for the year and even greater in winter. Along the western border of West Virginia the gradient is 1.7° per degree of latitude and at the eastern border of the Allegheny Plateau 2.0°.

Altitude exerts its influence on temperature over the Appalachian Highlands. It even becomes the dominant control. The vertical temperature gradient between Parkersburg and Bayard is 1.1° per 330 feet. It is greatest in summer.

There is a more uniform distribution of temperature in summer than in winter but the isotherms are more crowded over the Appalachian Highlands in summer. The general plan of the isotherms is much the same throughout the months, conforming largely to topographic conditions at all times. The isotherms reach their most southern limit in January but the northward advance is scarcely noticeable in February. In fall and early winter the ocean gives a northward bend and in summer a southward trend of the coastal portions of isotherms. Mean annual ranges of temperature are 34°–39° in the south and 40°–45° in the north. The regions of high altitude have a lesser range, while the modifying effect of the Atlantic shows in the slight range along the coast. The mean maximum and mean minimum isotherms have a tendency to parallel the coast, the ocean waters generally preventing great extremes of temperature. The absolute maxima temperatures range from 94° F. at Terra Alta and at Wytheville to 110° F. at Wheeling. The absolute lowest temperatures show great local diversities, the lowest being in the valleys. Lewisburg has reported −37° F. Lost Creek has the greatest annual range of temperature, 137 degrees, while Cape Henry has the smallest, 98 degrees.

There is a close correlation between frost and temperature maps. Also stations having much fog have longer frost-free periods than near-by ones without. Along the coast the last killing frost occurs before April 1, while at Bayard the average date is May 25; the average date of the first killing frost at Bayard is September 19, while over a part of the Tidewater it is later than November 10, thus the number of frost-free days ranges from 240 along the coast to 115 at the headwaters of the north branch of the Potomac.

The effect of the increase in latitude on frost is greatest along the Ohio border of West Virginia, where in a difference of 2.5° of latitude there is a change of 45 days in the frostless period.

Rainfall is well distributed through the year. The heaviest precipitation in the Virginias, 50 to 65 inches, falls on the west slope of the Alleghenies, while the lightest, 30 to 35 inches, involves a considerable area within the valley, lying in the lee of the higher lands.

Pickens, 2,697 feet, receives 65.08 inches of precipitation, while Charleston, 597 feet, in direct line up the prevailing winds from Pickens receives 46.02 inches, a difference of 9.1 inches per 1,000 feet of elevation.

The Appalachians cast their strongest rain shadow in winter and early spring, when the cloud base is lowest—the decrease from highland stations to lowland stations being 5 inches in January and 4 inches in each of the months December, February, and March, and only 2 inches in summer and fall. The influence of the Atlantic on precipitation appears to extend little, if any, beyond the Allegheny front.

For the most part summer is the season of heaviest precipitation, due to the persistence of the prevailing winds from the Gulf of Mexico and from the Atlantic. The large amount of moisture available at this season, therefore, yields abundant rainfall by local convectional activity, intensified now and then by summer cyclones.

Winter has abundant precipitation attending the almost constant procession of cyclonic storms.

Spring has the advantage of winter's accumulated precipitation and of marked changeableness of temperature, therefore precipitation is frequent but not so abundant as in winter or in summer.

Fall precipitation in the Virginias is low. Convectional activity has decreased and cyclonic influence has not yet become very marked.

The lowest average annual snowfall is 6.9 inches at Cape Henry and the greatest is 112.5 inches at Pickens. Snowfall increases with increase in latitude, altitude, and in general, decreases with proximity to the ocean. The Appalachians cast marked snow shadows over the valleys to leeward. Pickens, at 2,697 feet, with 112.5 inches and Woodstock at 927 feet, with 26 inches, show this shadow effect. Snow falls in some part of the Virginias 10 months of the year. In October snow has occurred everywhere in the Virginias except in a narrow belt along the Atlantic coast.

Thunderstorms occur in any month, but more than half of them in summer, the season of greatest convectional overturning. Elkins averages 28 during the summer and less than two during winter. This ratio holds, in general, for the other stations.

Hail is most frequent in spring and early summer, being more common in higher altitudes and more northerly latitudes.

The monthly course of absolute humidity runs parallel to the monthly course of temperature. Relative humidity increases with increase in latitude and altitude. April (except March, at Mount Weather) is the month of lowest relative humidity and September is the month of maximum.

Early fall is the period of maximum fogginess, except for stations of the coastal plain. At Cape Henry and Norfolk winter is the foggy season.

In the highland sections topography influences the wind direction, while on the coastal plain regularity in topography allows for a more even distribution of the winds. The strong northwest winds of winter change during the spring by way of west to a southwesterly or southerly direction in the summer months. Fall brings the northeast wind, which is most marked at stations on the coastal plain as there is less local topographic deflection here.

Wind velocities increase with altitude. An exception to this is found in the case of Elkins, however, which is influenced by local topography. The winter months are those of highest wind velocities and the maximum number of gales, but, except for Mount Weather and Cape Henry, there are few days with gales.

The Chicago snowstorm of March, 1930.—The discussion by Editor Alfred J. Henry of the storm of March 25, 1930, at Chicago, appearing in the MONTHLY WEATHER REVIEW of April, 1930, has been read with much interest, largely because a brief study has been made of the storm by us. Some general notions concerning the storm were deduced from a study of the 3-hour maps for the period. The weather was more insistently noticeable in its disastrous exhibition of snowy violence at Chicago but the Chicago-New York airway was under the domination of the changeable actions of the storm for two days and both summarizing and flying were difficult on this line. It is perhaps of interest to state that the summaries issued every three hours at this station were distinctly pessimistic as to the conditions at the western end of the airway (Chicago) until 5 p. m. March 26, 1930, when there appears this favorable sentence: "There will be an improvement in ceilings and lessening of snowfall in central Pennsylvania and ceilings will also rise somewhat at Chicago." The end of the snow was in sight at that time.

One of the similarities which is outstanding in comparing the 1888 blizzard with that of the present paper is that both storms had great depth as Professor Henry has stated, but also that they had two or three centers of depression. The 3-hour maps show these in distinct form by the wind motion and in the variations of pressure.

This study was instituted as a result of the phenomena observed here at Cleveland. About noon of March 25 conditions as observed indicated the passage of the center of the low, but again on March 26 about 7 a. m. another center passed. This dual action is traced across western and central Pennsylvania on the marginal charts of the same large sheet (not reproduced). The general conclusion is that a warm front dominated the conditions until the passage of the first depression; then there followed a period of cold with light winds but with little pressure recovery. Behind this came the pressure rise and a second temperature fall this time attended by westerly winds of definite drift.

Three stations on mountain tops, Greenwood, 175 miles east of Cleveland, elevation 2,300 feet; Winkelblech Mountain, 245 miles east of Cleveland, elevation 2,100 feet; and Park Place, 300 miles east of Cleveland, elevation 1,940 feet; were selected between here and New York for investigation as to the changes during the period of the passage of the depressions. These results are shown on the marginal spaces (not reproduced). The temperature drop at Greenwood occurred at 4 p. m. of the 25th, three hours later than at Cleveland, and shows different characteristics. At Winkelblech Mountain it occurred about three hours later than at Greenwood and at Park Place about three hours further. The warm front appears at each of the mountain stations but is brief and small at Cleveland. At Greenwood there was no fog in the warm front but a thunderstorm occurred when the front passed and a fog sets in when the cold front fully arrived, in this case fog being low clouds which covered the station. At Winkelblech there was fog in both fronts, a good example of a change of almost 20° in the dew point in six hours. At Park Place the fog occurred in both fronts, a drop of over 20° being shown in the dew point in 8 hours. Squalls first of rain and later of snow marked the weather at all three hill stations. The barometer readings shown were taken from corrected aneroids and are reliable.

On a set of four other "green" base charts we have drawn the squall line positions for the eight observations per day on the four days March 23 to 26, inclusive (not reproduced). In general these lines show a normal direction of movement and twist but an abnormally slow motion.

Two other charts show that the identification of one of the three subcenters from hour to hour is fairly plain although the small changes in the central pressure and circulation are not even fully discounted by stations as closely adjoining as those of the airway service. These maps have not been inclosed. Another feature of unusual interest is the fact that pressure in the area east of the ninety-second meridian failed to show any considerable rise for a period of three days. Increases of 0.06 inch or more per three hours were only seven in number for the entire period from 5 p. m. March 23 to 8 a. m. March 26. The falls were numerous, showing plainly the increasing intensity of the storm and its spreading power. As is frequently true of lows in this area it is generally true that it is unsafe to predict betterment of conditions whatever the wind and temperature may show if the pressure fails to recover in their rear, or if it settles somewhat.

One feature of the pressure distribution which called our attention toward the chance for a developing storm was the pressure trough on the central Gulf coast. Our conclusion that the storm was retarded by this low is about as strong as our conclusion that the northeastern "high" blocked its progress, and we believe that the masses of warm air associated with this small Gulf disturbance had to find an outlet to the north with the natural result that they tended to reduce pressures there.

Reference was made in the REVIEW to upper air motions. Few balloon runs were obtained here but the upper clouds when observed were from compass points having considerable south component. No data available appear to have given us any reasonable basis for expecting the great development which did occur.

Strangely enough, it was one storm in which the lonely observer with one aneroid barometer was more likely to have made a successful set of predictions than were some of the more completely informed forecasters with a wide field of pressure readings. The explanation for this is reasonable when we take one isobar such as the 29.7 and draw its position for each three hours, thus depicting its steady and wide expansion and at times its actual movement toward the west on the western sides of its curve.

C. G. ANDRUS, *Meteorologist.*

Weather conditions during the summer of 1930.—The drought in the United States during the months of July and August, 1930, was paralleled in Europe by a period of rain and cold not equaled since 1864, it is stated. Although the first week of July was dry and warm, the average daytime temperature for the entire month was 0.7° C. below normal; the average maximum temperature was 0.8° below normal, but the average minimum was 0.1° above normal owing to the warm weather during the first week. During the first 20 days of August the average morning, maximum, and minimum temperatures were respectively 1.0°, 1.5° and 0.5° below normal.

The precipitation of moisture during the month of July averaged 142 millimeters (5.59 inches), the normal being 71 millimeters or 2.79 inches, this having been the wettest month since 1855, according to the records of the weather service. The rainfall during the first 20 days of August was almost 100 per cent above normal, and furthermore there were heavy winds on several occasions which did much damage to the growing crops.

The number of hours of sunshine during July was 180, of which 70 hours were credited to the first seven days, the total thus having been 86 hours below the normal of 196 hours. During the first 20 days of August the number of hours of sunshine was 101 while the normal number is 116. A total of 42 hours of the entire number of hours of sunshine up to the 20th of the month occurred during the last four days of the period. *U. S. Consular Report.*

Ergebnisse der Registrierballonfahrten ausgeführt vom Geophysikalischen Institut der Universität Leipzig und der Sächs. Landeswetterwarte in den Jahren 1926 u. 1927.—The results of the sounding-balloon ascents at Leipzig in 1926 and 1927 have been published in mimeographed form, including brief discussion and both tables and graphs for each ascent. The frequent occurrence of minor temperature inversions in the free air is striking, as is also the usual coincidence of the maximum of relative humidity with the beginning of a temperature inversion. Temperature-isopleth diagrams for certain series of days show in one instance a sharp oscillation in the course of a single day, and extending to a height of 10 or more kilometers, with approximately the same amplitude, of 5° C. at all heights. A minor low was passing.—*C. F. B.*

P. R. Krishna Rao on the distribution of temperature in the lower stratosphere.[1]—The author has shown by means of graphs and tables some striking relationships between the inversion in the lower part of the stratosphere and the temperature at the tropopause (Tc). It is found that lower values of Tc are associated with thicker and stronger inversions in the lower layers of the stratosphere. It is also shown from the mean annual lapse rates that the stratospheric inversion is only about 3 to 4 km. thick in the temperate regions but much thicker in the tropical and subtropical regions. The upper limit of this inversion in the latter regions is above the highest altitudes reached by observations thus far.

The fact is pointed out that the stratosphere is not an isothermal region as it is sometimes believed to be but a region that definitely begins with an inversion of temperature. The following qualitative explanation is given for the existence of this inversion and its latitudinal variation and for the relationship between Tc and the strength and thickness of the inversion on the basis of convection in the troposphere:

It is well known that the actual temperature distribution in the atmosphere is not determined by radiation alone but is fundamentally influenced by turbulence and convection in the region of the lower atmosphere in which the water vapor content is appreciable. The effect of superposing convection on radiation equilibrium condition is to increase the temperature in the lower layers mainly by the latent heat liberated from the condensation of water vapor. Active convection may be expected to continue up to the height at which the equivalent potential temperature [2] is the same as the equivalent potential temperature at the starting point (ground). Above this limit, there will be a certain amount of "forced mixing" due to the disturbance caused by the convection below. This mixing will cool the upper layers because the lower layers are potentially colder than the upper. The tropopause can make its appearance only above this region of forced mixing. If the convection below is sufficiently active this mixing will raise the tropopause and lower the temperature there below the radiation equilibrium temperature of the stratosphere.[3] As there can be no convection above the tropopause there will be a tendency to go back to the radiation equilibrium temperature. This approach from a lower to a higher temperature results in an inversion.

The stronger the convection the greater is the cooling in the uppermost regions of the troposphere which produces lower values of Tc and hence stronger inversions above. Since on the average there is more convection in the tropics than in the temperate regions and more in summer than in winter, it follows that the stratospheric inversion should be stronger in the tropical than in the temperate region and stronger in summer than in winter. The height range through which the approach from Tc to the radiation equilibrium temperature of the stratosphere occurs determines the thickness of the inversion above the tropopause; this is larger, the larger the deviation of Tc from the radiation equilibrium temperature of the stratosphere.

If the stratospheric inversion owes its origin to convection in the troposphere, we should expect some significant relationships of temperatures and lapse-rates in the troposphere with Tc and the stratospheric inversion. Some preliminary calculations have shown that there is a strong negative correlation between the temperature at 10 gkm. and the fall of temperature between 10 and 16 gkm. over Agra. (16 gkm. is about the mean height of the tropopause over Agra). Blair [4] has shown from American observations that the seasonal variation in the height of the region of largest lapse-rates in the troposphere is similar to the variations of the height of the minimum temperature in the free atmosphere. This seems to hold for other places also.

The author states that:

for various reasons, viz, the existence of maximum concentration of ozone in the atmosphere at a height of 30–50 km., the reflection of sound waves from the upper atmosphere and Lindemann and Dobson's theory of meteors, it is, however, fairly certain that above 40 km. there is a rapid increase of temperature with height.

This opinion is not yet held by many meteorologists since all of the phenomena mentioned can be satisfactorily accounted for in other ways.—*L. T. Samuels.*

[1] India Meteorological Department. Scientific Notes, Vol. I, No. 10.

[2] Equivalent potential temperature θ is the temperature which would be taken up by a mass of air at "equivalent temperature" θ when brought adiabatically from its pressure to a pressure of 1,000 mb. $\theta = T \times \frac{Lx}{c}$ where T is the dry bulb temperature, x the humidity-mixing ratio corresponding to the existing vapor pressure at T, c the specific heat of air at constant pressure and L the latent heat of condensation. For greater details refer to Ind. Met. Memoirs, Vol. XXIII, Part I.

[3] According to the "classical" radiation equilibrium theory the temperature distribution with height is practically isothermal at 220° A. See Die Arbeiten des Preuss: Aeronautischen observatorium bei Lindenberg Band XIII, p. 6.

[4] Bull. of Mt. Weather Obs'y, Vol. IV, p. 6.

BIBLIOGRAPHY

C. FITZHUGH TALMAN, in Charge of Library

RECENT ADDITIONS

The following have been selected from among the titles of books recently received as representing those most likely to be useful to Weather Bureau officials in their meteorological work and studies:

Davison, A. E.
Dancing conductors. 6 p. figs. 30½ cm. (Presented summer convention of A. I. E. E., Toronto, June 23–27, 1930.) [Swinging of ice-laden wires in the wind.]

Febrer, Joaquim.
Atlas pluviometricède Catalunya. Barcelona. 1930. 523 p. charts. 28½ cm. (Memòries Patxot. v. 1.)

Fleming, Robins.
Wind stresses in buildings, with a chapter on earthquakes and earthquake resistance. New York. 1930. xi, 193 p. illus. diagrs. 23½ cm.

Folse, J. A.
New method of estimating stream-flow based upon a new evaporation formula. Washington. 1929. xi, 237 p. plates. 29½ cm. (Carnegie inst. Washington. Pub. no. 400.)

Great Britain, Meteorological office.
Currents on the main trade routes of the North Atlantic ... London. 1930. charts. 40 cm.
Instructions for meteorological telegraphy, embodying the new international codes approved by the international meteorological conference at Copenhagen in September 1929. London. 1930. 62 p. plates. 24 cm. (Met'l observer's handbook suppl. no. 1 (2nd ed.).) (M. O. 191/1 (1930).)
Weather map, an introduction to modern meteorology. 2nd ed., entirely rewritten. London. 1930. iv, 83 p. figs. charts. 24½ cm. (M. O. 225i.)